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(54) Titre : METHODE POUR L'OBTENTION DE GRANULES PLASTIQUES EXPANSIBLES
(54) Title: METHOD FOR THE PRODUCTION OF EXPANDABLE PLASTICS GRANULATE

(57) Abrégé/Abstract:
In a method for the production of expandable plastics granulate (C) a plastics melt (A') is impregnated by a fluid blowing agent (B), the blowing agent being at an elevated pressure within a predetermined pressure range only partly soluble in the melt. The method comprises the following steps: 1. dispersion of the blowing agent in the melt, 2. retaining of the mixture within a predetermined pressure range for a predetermined retention time, 3. cooling of the melt impregnated by the blowing agent to a temperature which is several °C above the solidification temperature of the melt, and 4. granulating the cooled mixture. According to the invention the mixture is acted upon by static mixing elements and by this mixing is avoided segregation.

METHOD FOR THE PRODUCTION OF EXPANDABLE PLASTICS GRANULATE

The invention relates to a method for the production of expandable plastics granulate and equipment and plant for carrying out or using the method.

An often used foamed plastics is made of polystyrene. In this process granulate of "expandable polystyrene", EPS, is processed into blocks or moulded parts, while in an intermediate step the granulate is prefoamed. EPS may be manufactured by suspension polymerization. In that process styrene is polymerized in an aqueous phase with the addition of a blowing agent. In this way a bead-shaped granulate is produced within a wide range of bead sizes. A disadvantage of this method is that large quantities of water, which must be cleaned, accumulate and that the granulate is usable for the production of the foamed material only within a limited range of sizes so that a considerable part of the produced polymer must be discarded (or recycled).

In another method, which is little suitable for the production of large quantities of EPS, the polystyrene is, after polymerization, impregnated by a blowing agent in pressure vessels or in extruders. The product is cylindrical granulate.

Further information on foamed materials can be found in Ullmanns Encyklopädie der technischen Chemie (4th edition, 1981), volume 20, pages 415 to 432 and volume 19 pages 268 and 131.

The aim of the invention is to provide a method of economical production of expandable plastics granulate,

for instance of EPS, by which may be produced large quantities without the disadvantages of the known methods. According to this method a plastics melt is impregnated with a fluid blowing agent which is, at elevated pressure within a given pressure region, only partially soluble in the melt.

In accordance with the broad aspect of the present invention, a method is provided for the production of expandable plastics granulate from a plastics melt and a fluid blowing agent which is at an elevated pressure within a predetermined pressure range only partly soluble in the melt, the method comprising the following steps:

-dispersion of the blowing agent in the melt,
-retaining of the mixture within a predetermined pressure range for a predetermined retention time,
-cooling of the melt impregnated by the blowing agent to a temperature which is several °C above the solidification temperature of the melt, and
-granulating the cooled mixture,

the method being characterized in that the mixture is acted upon by static mixing elements and by this mixing is avoided segregation.

In another aspect and still defining the invention in broad terms, an equipment is provided for carrying out the above method which is characterized by one or more static mixers for the impregnation of the plastics melt by the fluid blowing agent, a cooler for the impregnated melt whose heat exchange elements are in the form of built-in elements of the static mixer, and a granulator.

In another aspect of the present invention, a plant is provided which includes the equipment as defined above and which comprises, in addition, the following parts:

be dissipated.

The dependent claims 2 to 4 relate to advantageous embodiments of the method according to the invention. They relate in detail to an efficient method for the impregnation of the plastics melt by the blowing agent, a simple method for the cooling of the impregnated mixture and a useful method of granulation. By the feature of claim 5, namely addition not only of a blowing agent but also several additives to the melt, the quality of the product can be advantageously influenced. As a blowing agent is used a chlorofluorocarbon or preferably a low-boiling hydrocarbon, particularly pentane, or a mixture of such hydrocarbons. As additives may be used flameproofing agents (compounds of bromine), lubricants (oil, derivatives of stearic acid), dyes, antioxidants, softeners or nucleators (for the formation of cells).

The dependent claims 7 to 10 relate to advantageous embodiments of the equipment according to the invention and the dependent claims 12 to 14 relate to various possible applications of the plant according to the invention.

The invention will now be explained in greater detail with reference to the drawings. In the drawings:

Fig. 1 is a block diagram for the explanation of the plant or method according to the invention,

Fig. 2 shows qualitatively represented course of the pressure p for the equipment according to the invention,

Fig. 3 shows the course of pressure in a second

equipment, and

Fig. 4 is a diagram for a plant for the production of EPS according to the invention.

In the block diagram of Fig. 1 the reference numerals 1 to 4 relate to the four method steps referred to in the preamble of claim 1: dispersion 1, retention 2, cooling 3 and granulation 4. To these method steps correspond in the pressure diagrams of Figures 2 and 3 the intervals I, II, III, IV. Because the individual blocks of the diagram in Fig. 1 are interpreted as parts of the plant, the same references may be used for the plant parts in Fig. 4 as in the block diagram. In Fig. 1 are these plant parts 1, 2, 3, and 4 arranged linearly in the direction of the x-axis. The raw materials for the method are a plastics A (or a monomer A) and a blowing agent B (possibly with the addition of one or more additives); the product is the expandable plastics granulate C to be produced.

Fig. 1 shows - interpreted as a plant - the following parts: a source 10 of plastics with a tank 9 for A and a device 11 in which is produced a gas-free plastics melt A'; a source 20 of blowing agent with a tank 19 containing B and a device 21 by means of which B can be metered; a control unit 30 by means of which the amount of B can be adjusted to the amount of A'; and finally the equipment 1, 2, 3, 4, in which is carried out the method according to the invention.

In the dispersion step 1 the melt A' is mixed at elevated pressure with the blowing agent B, the melt being subjected to extensive shearing so that the liquid blowing agent is dispersed in the melt in the form of

fine droplets. During a predetermined retention time in the step 2, the blowing agent partly diffuses in the melt. Impregnation, which is carried out in both the first two steps, proceeds preferably at a temperature which lies considerably above the solidification temperature of the melt. Because the higher the temperature the smaller the viscosity of the melt and the better proceeds the distribution of the blowing agent.

In the cooling step 3 the temperature of the melt impregnated by the blowing agent is reduced several °C above the solidification temperature of the melt. The cooled mixture is then in the last step 4 transformed to granulate form.

To avoid any segregation during the passage through the equipment 1, 2, 3, 4, the mixture is kept in motion in all method steps and also during transfer from one step to the next; this is achieved, according to the invention, by using static mixing elements.

The source 10 of plastics may contain a polymerization reactor for the production of the plastics A' from a monomer raw material A and also a degassifier for the polymer. The source 10 of plastics may also include a recycling device for the recycling of the thermoplastic and a melting device. The thermoplastic should be preferably of the same kind. Also a melting device for a granular thermoplastic may be used as a source of plastics. For instance a heatable extruder may be used as the melting device.

Fig. 2 shows qualitatively the course of pressure p in the four method steps. During the dispersion, interval I, the pressure drop is due to the extensive shearing

relatively large compared with the pressure drop in the second step, interval II. The cooling, interval III, takes place again with a larger pressure drop which is the result of provisions for achieving efficient heat exchange. During the granulation step, interval IV, the mixture is extruded through nozzles while the pressure sharply drops. So as to avoid expansion of the formed strands by the blowing agent, the extruded mixture must be abruptly cooled by a coolant, preferably water.

Between the steps 1 and 2 and/or steps 2 and 3 may be provided pumps by means of which the pressure is again increased. This is shown in Fig. 3, where the intervals I' and II' are associated with such provisions.

In the embodiment shown in Fig. 4 the source 10 of plastics is formed by a polymerization reactor 12 for the production of polystyrene from the monomer raw materia A (styrene), by a degassifier 14 for the polymer and two gear pumps 13 and 15. The blowing agent B (for instance n-pentane) is fed to the melt A' by a metering piston pump 21.

The impregnation is performed in the unit 1, 2 at an initial pressure of e.g. 100 bar (≈ 10 MPa) and a temperature of about 200 °C. This unit preferably contains a first static mixer, a "shearing mixer" 1 for the dispersion of the blowing agent and a second static mixer, a "retention time mixer" 2, situated immediately next to the first one and serving for diffusive transport of the blowing agent into the melting phase. (The two mixers 1 and 2 are not shown in Fig. 4 as e.components.) In the shearing mixer 1 is performed the dispersion with more intensive shearing of the melt while fine droplets of the blowing agent are formed. The intensive shearing

is achieved by a high flow rate. In the retention time mixer 2 the mixture is subjected, during a retention time needed for the diffusive transport, to little shearing. The uneven flowing conditions in the two mixers are obtained in that the second mixer is made with a much larger cross-sectional area than the first one.

A gear pump 5 pumps the impregnated melt into the unit 3 in which is combined mixing by static means with heat exchange. Preferably a device known from DE A 28 39 564 is used, namely: a static mixer whose crossing elements are made as heat exchange pipes. The pressure drop is, for instance, 100 bar and the initial temperature about 120 °C. As a cooler may be used, for instance, a heat exchanger containing a bundle of pipes in whose individual pipes are provided with static mixing elements.

Finally the impregnated and cooled melt is, in a strand granulator 4, which contains a nozzle plate, a cooling bath and a cutting device (not shown), converted into the desired product C, namely EPS. The pressure drop upstream of the nozzle plate is at least 10 bar. As a cooling bath is used a cooling water bath (about 10 °C). The strands emerging from the nozzles (diameter smaller than 1 mm) are first cooled and finally cut by a cutter with several blades. The product is a granulate with granulate grains of uniform size. As a consequence - in contrast to the suspension polymerization mentioned at the beginning - the whole product may be used for the production of foamed plastics.

As a granulation device may be used, apart from the strand granulator, also a hot strand chopping granulator or a so-called underwater granulator. In the underwater

granulator may be made granulate whose grains have practically the same shape as the granulate grains produced by suspension granulation.

CLAIMS

1. Method for the production of expandable plastics granulate from a plastics melt and a fluid blowing agent which is at an elevated pressure within a predetermined pressure range only partly soluble in the melt, the method comprising the following steps:

- dispersion of the blowing agent in the melt,
- retaining of the mixture within a predetermined pressure range for a predetermined retention time,
- cooling of the melt impregnated by the blowing agent to a temperature which is several °C above the solidification temperature of the melt, and
- granulating the cooled mixture,

the method being characterized in that the mixture is acted upon by static mixing elements and by this mixing is avoided segregation.

2. Method according to claim 1, characterized in that the dispersion takes place with extensive shearing of the melt while fine droplets of the blowing agent are formed and that the mixture is then during a predetermined retention time subjected to little shearing.

3. Method according to claim 1 or 2, characterized in that the cooling of the mixture and the simultaneously performed mixing are carried out at least partly by the same components.

4. Method according to any one of claims 1 to 3, characterized in that the cooled mixture is extruded through nozzles and the formed strands are chilled by a coolant and by disintegration formed into granules.

5. The method of claim 4, wherein the coolant is water.

6. Method according to any one of claims 1 to 5, characterized in that in addition to the blowing agent at least one additive is added to the plastics melt.

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7. Equipment for carrying out the method according to any one of claims 1 to 6, characterized by one or more static mixers for the impregnation of the plastics melt by the fluid blowing agent, a cooler for the impregnated melt whose heat exchange elements are in the form of built-in elements of a static mixer, and a granulator.

8. Equipment according to claim 7, characterized in that a first static mixer for the dispersion of the blowing agent and a second static mixer, which follows directly after the first one and serves for impregnation are provided.

9. Equipment according to claim 7 or 8, characterized in that the cooler is a static mixer whose elements crossing each other are formed as heat exchanging pipes.

10. Equipment according to any one of claims 7 to 9, characterized in that the granulator comprises a nozzle plate, a cooling bath and a cutting device.

11. Equipment according to any one of claims 7 to 10, characterized in that between the mixers for the impregnation of the plastics melt and the cooler is provided a pump for the melt.

12. The equipment of claim 11, wherein the pump is a gear pump.

13. Plant including an equipment according to any one of claims 7 to 12 which comprises, in addition, the following parts:

- a source of plastics in which may be produced the plastics melt,
- a source of blowing agent by means of which may be carried a metered supply of the blowing agent, and
- a control unit for controlled supply of the blowing agent adjusted according to the flow of melt.

14. Plant according to claim 13, characterized in that the source of plastics comprises a polymerization reactor for the production of the plastics from a monomer raw material and a degassifier for the polymer.

A

7. Equipment for carrying out the method according to any one of claims 1 to 6, characterized by one or more static mixers for the impregnation of the plastics melt by the fluid blowing agent, a cooler for the impregnated melt whose heat exchange elements are in the form of built-in elements of a static mixer, and a granulator.

8. Equipment according to claim 7, characterized in that a first static mixer for the dispersion of the blowing agent and a second static mixer, which follows directly after the first one and serves for impregnation are provided.

9. Equipment according to claim 7 or 8, characterized in that the cooler is a static mixer whose elements crossing each other are formed as heat exchanging pipes.

10. Equipment according to any one of claims 7 to 9, characterized in that the granulator comprises a nozzle plate, a cooling bath and a cutting device.

11. Equipment according to any one of claims 7 to 10, characterized in that between the mixers for the impregnation of the plastics melt and the cooler is provided a pump for the melt.

12. The equipment of claim 11, wherein the pump is a gear pump.

13. Plant including an equipment according to any one of claims 7 to 12 which comprises, in addition, the following parts:

- a source of plastics in which may be produced the plastics melt,
- a source of blowing agent by means of which may be carried a metered supply of the blowing agent, and
- a control unit for controlled supply of the blowing agent adjusted according to the flow of melt.

14. Plant according to claim 13, characterized in that the source of plastics comprises a polymerization reactor for the production of the plastics from a monomer raw material and a degassifier for the polymer.

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15. Plant according to claim 13, characterized in that the source of plastics comprises a recycling device for the recycling of a thermoplastics and a melting device.

16. The plant as recited in claim 15 wherein the melting device is a heated extruder.

17. Plant according to claim 13, characterized in that the source of plastics is a melting device.

18. The plant as recited in claim 17, wherein the melting device is a heated extruder for a granulate.

19. Use of a plant according to claim 13 for the production of "expandable polystyrene", EPS, from newly produced or recycled polystyrene, while a hydrocarbon is used as the blowing agent.

20. The use of a plant as recited in claim 19, wherein the hydrocarbon used as the blowing agent is a low boiling hydrocarbon.

21. The use of a plant as recited in claim 20 wherein the low boiling hydrocarbon is pentane or a mixture of low boiling hydrocarbons.

ABSTRACT

In a method for the production of expandable plastics granulate (C) a plastics melt (A') is impregnated by a fluid blowing agent (B), the blowing agent being at an elevated pressure within a predetermined pressure range only partly soluble in the melt. The method comprises the following steps: 1. dispersion of the blowing agent in the melt, 2. retaining of the mixture within a predetermined pressure range for a predetermined retention time, 3. cooling of the melt impregnated by the blowing agent to a temperature which is several °C above the solidification temperature of the melt, and 4. granulating the cooled mixture. According to the invention the mixture is acted upon by static mixing elements and by this mixing is avoided segregation.

(Fig. 1)

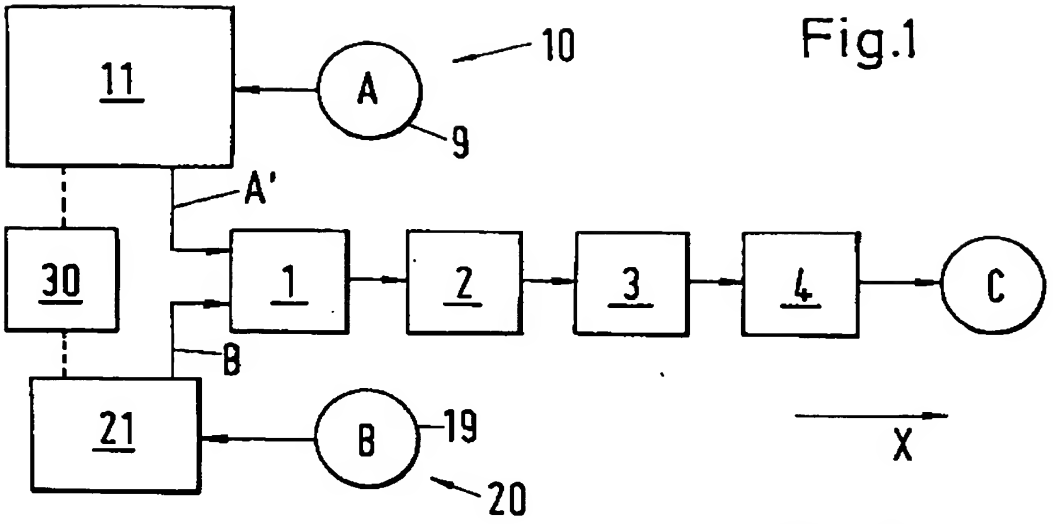

Fig.1

Fig.2

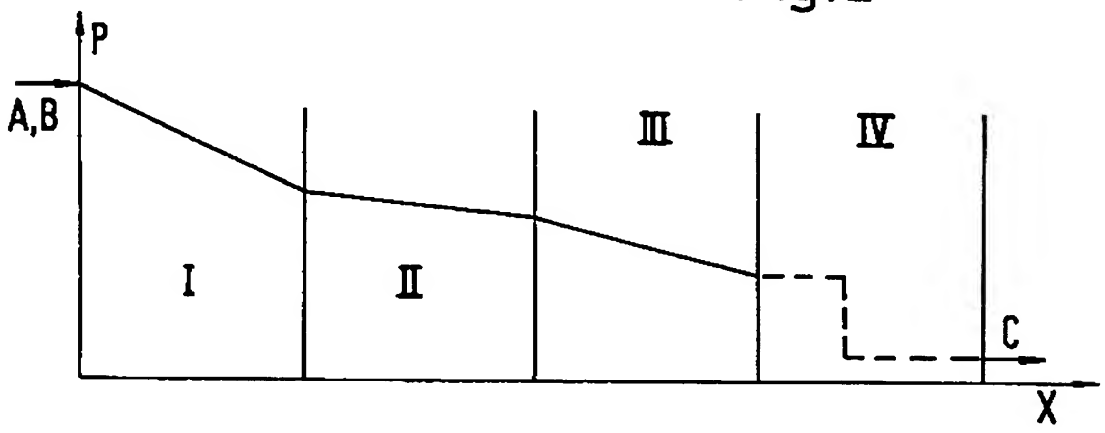

Fig.3

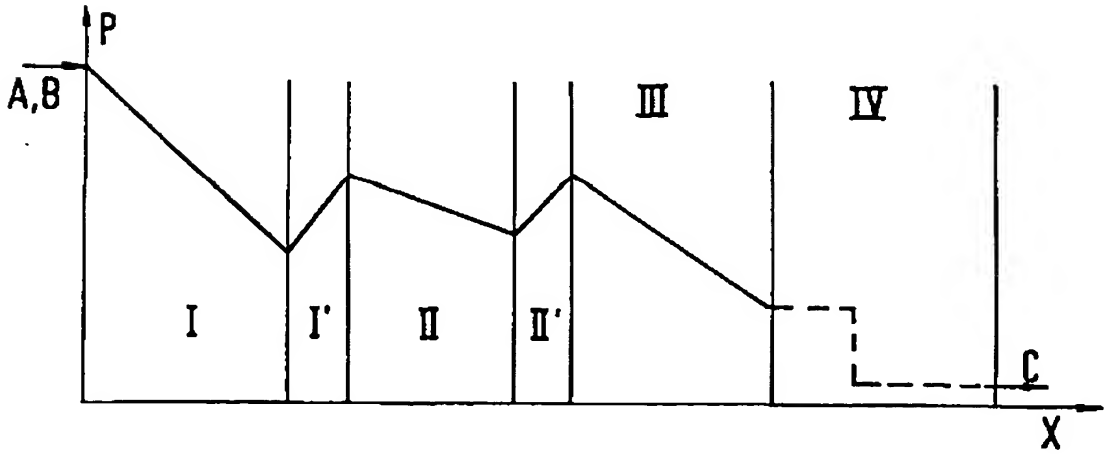

Fig.4